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in cooperation with
THE CLEMSON AGRICULTURAL COLLEGE
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THE AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

TESTS OF IRRIGATED AND RAIN-GROWN AMERICAN UPLAND COTTON, CROP OF 1939

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Prepared by the
Agricultural Marketing Service 1/

INTRODUCTION

The relative manufacturing quality and use-value of irrigated and rain-grown American upland cotton have been the subject of discussion and controversy among growers, shippers, and manufacturers in this country since the early 1920's, when the growth of cotton on irrigated land began to assume importance. The opinion of American and foreign spinners in regard to irrigated cotton is rather varied. Some evidently have found that it meets their requirement satisfactorily. Many others complain, however, that irrigated cotton is less desirable than rain-grown cotton of the same grade and staple length. Specifically, they say that irrigated cotton is weak, irregular in staple length, and wasty; that the yarns spun from it are weak and rough; that the fabrics contain many neps which detract from their appearance; and that the yarn and fabric do not absorb dye to the same degree as rain-grown cotton.

The net effect of these complaints is that for a number of years irrigated cotton has brought a lower price than corresponding grades and staples of rain-grown cotton. When it is realized that about 780,000 bales of upland cotton were grown under irrigation in California, Arizona, New Mexico, and West Texas, during the 1939 season, it may be seen that the problem is of vital concern to growers of this cotton. Although these producers have made concerted efforts to improve the quality of their cotton, this attitude, or "discrimination," on the part of the manufacturers continues to exist. The producers have asked the Department to obtain accurate, unbiased information regarding the relative quality of irrigated cotton and of rain-grown cotton of the same grades and staples.

1/ This report was prepared by Malcolm E. Campbell, Senior Cotton Technologist, Agricultural Marketing Service, who directed the tests. The manufacturing tests were conducted under the supervision of John M. Cook, Associate Cotton Technologist, in the laboratories of the Agricultural Marketing Service at Clemson, S. C., in cooperation with the Clemson Agricultural College. The fiber tests were conducted under the supervision of John T. Wigington, Associate Cotton Technologist, in the Service's laboratories at College Station, Texas, in cooperation with the Agricultural and Mechanical College of Texas. W. B. Lanham, Senior Agricultural Economist, supervised the collection of the test samples.

Likewise, the Department has received many similar requests from cotton manufacturers. With the increased use of research and testing in the textile industry, manufacturers are paying more attention to the quality of their products and, consequently, to the raw material used to make them. Increased competition, particularly in connection with quality specifications for automobile tire cord and other cotton products for "mechanical" purposes, has stimulated a search for the best cotton for each use, at a price the manufacturer can afford to pay. It is well known that there is considerable variation in the quality of cotton between varieties, between producing areas for a given crop, and between crops. Under the circumstances it is natural, therefore, that the possibilities of substituting various kinds of cotton, including irrigated cotton, for other growths should receive increased attention from the manufacturers.

It was in response to these requests from producers and mill men that the investigation described in this report was conducted. No attempt has been made to justify or discredit the opinions of the cotton trade with respect to irrigated cotton, nor to indicate the extent to which differences in manufacturing quality between different growths are or should be reflected in price differentials. It is the purpose of the report merely to present the facts as they were observed for selected composite lots of irrigated and rain-grown American upland cotton.

The results here presented are for one season only, namely, the crop of 1939. Before generalized conclusions can be drawn regarding the relative quality of irrigated and rain-grown cotton on the basis of such a laboratory investigation, it will, of course, be necessary to obtain information of a similar type for other crop years.

DESCRIPTION OF COTTONS TESTED

The cottons tested were produced commercially in three sections of the United States Cotton Belt: (1) California, (2) Arizona, New Mexico, and west Texas, and (3) the Mississippi Delta. The first two regions include nearly all the area in which cotton is grown under irrigation in this country. The third area is the principal one producing medium and long staple cottons which compete directly with irrigated cotton. Facilities were not available for including in these tests rain-grown cottons from other areas producing qualities of cotton that are directly competitive with irrigated cotton.

In obtaining the material to be used for this study, the primary objective was to obtain a group of samples as representative as possible of the commercial crop with respect to certain predomi-

nating grade and staple combinations in each of the three areas. The use of test lots composed of from about 250 to 300 bale samples each appeared to offer the best solution to this problem.

A total of approximately 130,000 bale samples of the grades and staples included in this study were collected during the 1939 season at three of the field offices of the Agricultural Marketing Service. These offices were located at (1) Bakersfield, Calif., serving the State of California; (2) El Paso, Texas, serving the Rio Grande Valley of Texas, the Mesilla Valley of New Mexico, and the Salt River Valley of Arizona; and (3) Memphis, Tenn., serving the Delta areas in Mississippi, Arkansas, and Louisiana. The samples were collected throughout the season from 5 to 10 percent of the gins in each area, primarily for use in connection with estimates of the grade and staple of the cotton crop. From the 130,000 samples, approximately 20,000 samples were carefully selected and composited into 81 test lots for use in this study.

From each of the 3 areas, an effort was made to obtain triplicate test lots for each of 12 grade and staple combinations. These included 4 grades, Good Middling, Strict Middling, Middling, and Strict Low Middling, and 3 staple lengths, 1-1/16, 1-3/32, and 1-1/8 inches. Such a plan would have resulted in 108 test lots if all the desired samples had been available. In some instances, however, it was not possible to obtain the material required, and so this total was reduced to 81 test lots.

Table 1 shows the number of bale samples per lot used in the test, listed according to area, staple length, and grade for each of the three sets of lots.

TEST PROCEDURE

Each of the test lots was subjected to detailed fiber studies, which included determinations of length and length variability, strength, weight per inch, and percentage of thin-walled fibers. Each lot was manufactured into three counts of yarn, and into automobile tire cord. The lots designated as Set 1 were also made into a narrow sheeting, portions of which were bleached and dyed.

During manufacturing, detailed studies were made of waste and general manufacturing characteristics, and the samples of yarn, cord, and fabric were subjected to thorough tests to provide as complete a picture as possible of the quality of the products made from each of the lots.

Table 1. - Number of samples per lot tested, irrigated and rain-grown cottons, crop of 1939

Set No. and grade	Miss., Ark., La.			Calif.			Ariz., N. M., Texas			Total
	1-1/16 inches	1-3/32 inches	1-1/8 inches	1-1/16 inches	1-3/32 inches	1-1/8 inches	1-1/16 inches	1-3/32 inches	1-1/8 inches	
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Set No. 1										
G.M.	210	103	101	259	254	256	250	250	250	1933
S.M.	249	240	250	270	254	266	250	250	223	2252
M.	248	240	247	262	264	286	250	250	250	2297
S.L.M.	251	250	250	275	301	246	134	104	0	1811
Set No. 2										
G.M.	0	94	0	247	253	0	250	250	0	1094
S.M.	249	249	245	259	262	242	250	250	0	2006
M.	251	249	240	304	269	280	250	250	0	2093
S.L.M.	245	244	0	256	242	247	0	0	0	1234
Set No. 3										
G.M.	0	0	0	0	0	0	250	250	0	500
S.M.	249	248	0	251	255	247	250	250	0	1750
M.	250	244	0	267	274	266	250	0	0	1551
S.L.M.	248	250	0	248	242	254	0	0	0	1242
Total	2450	2411	1333	2898	2870	2590	2384	2104	723	19763
		6194			8358			5211		

Figure 1 shows the organization followed in spinning each of the yarns. Further details relating to the fiber tests and the manufacture and testing of the yarns, cords, and fabrics may be found in the Appendix to this report.

RESULTS

(1) Fiber tests. Table 2 shows for each grade and staple combination for each area, the fiber length (upper quartile and mean), coefficient of length variability, fineness in terms of micrograms per inch, immaturity in terms of percentage of thin-walled fibers, and fiber tensile strength in terms of thousands of pounds per square inch as determined by the Chandler bundle method. In the case of length, length variability and strength, each figure is the average for three, two, or one sets, depending upon the availability of the cottons. (See table 1.) For fineness and immaturity, each figure is the average for set No. 1 only. In table 14, which is a summary table presented later in the report, the fiber properties and other values have been averaged according to length and producing area. Reference will be made to both tables 2 and 14 in the following discussions.

(a) Length. From the standpoint of upper quartile length, which is the length at the upper 25 percent point in the fiber array, the agreement among corresponding areas is quite close, with the possible exception of the 1-1/8 inch cotton. In this length, it may be seen that the rain-grown samples are a little longer (about 0.03 or 1/32 inch) than the irrigated samples. In mean length, there is a distinct trend downward for all staple lengths, from the rain-grown or Delta cottons, through the California cottons to the lots from the Arizona-New Mexico-Texas area. These differences are reflected directly in the coefficients of length variability, which are seen to increase in the same direction. In other words, length for length, on an average the rain-grown samples are more uniform in fiber length, with the California cotton second and the Arizona-New Mexico-Texas cotton third.

(b) Fineness. The Delta cottons were on an average 9 or 10 percent heavier in fiber weight per inch than the irrigated cottons. Differences between the two irrigated growths were inconsistent, and the two averages for them differed only to a negligible degree.

In most cases the longer stapled cottons were lighter in weight per inch. This is in line with other findings obtained in the Service's laboratories.

(c) Immaturity. In percentage of thin-walled fibers, the lots from the different growths varied only slightly, on an average. Only two lots possessed more than 30 percent of such fibers,

PICKER LAP		CARD SLIVER	DRAWING SLIVER		ROVING			YARN	
BREAKER	FINISHER		FIRST	SECOND	SLUBBER	INTERMEDIATE	FINE FRAME		
OZ. PER YARD	OZ. PER YARD	GR. PER YARD	GR. PER YARD	GR. PER YARD	HANK	HANK	HANK	COUNT	USE
			40.0	40.0	1.00	2.93	10.00	60s	TEST
13.75	11.00	40.0					7.35	44s	TEST
			43.6	47.5	.74	2.00			
								23.6s	FILLING
								23.0s	TIRE CORD
							5.50		
								22.0s	TEST
								21.0s	WARP

FIGURE 1.– WEIGHT OR SIZE OF STOCK MADE AT EACH MACHINE DURING THE MANUFACTURE OF THE YARNS.

Table 2. - Fiber properties of irrigated and rain-grown cottons tested, crop of 1939

Fiber property and grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
U.Q. length (inches)									
G.M.	1.197	1.217	1.224	1.224	1.237	1.253	1.295	1.262	1.293
S.M.	1.218	1.239	1.209	1.233	1.252	1.254	1.311	1.276	1.289
M.	1.221	1.240	1.199	1.271	1.253	1.255	1.303	1.271	1.276
S.L.M.	1.228	1.225	1.210	1.284	1.256	1.259	1.333	1.281	---
Mean length (inches)									
G.M.	.998	.965	.974	1.038	.998	.990	1.102	1.045	1.053
S.M.	1.008	1.004	.966	1.028	1.008	1.012	1.094	1.033	1.023
M.	1.005	.996	.949	1.048	1.013	1.011	1.046	1.049	1.036
S.L.M.	.992	.979	.948	1.027	1.014	.984	1.092	1.061	---
Coef. var. (%)									
G.M.	28.5	35.3	34.8	27.6	33.5	35.4	25.4	30.5	32.4
S.M.	29.8	32.7	34.3	29.9	33.7	33.0	28.5	32.6	33.8
M.	30.8	33.6	35.1	30.2	33.0	32.9	33.2	30.1	32.3
S.L.M.	33.7	34.1	36.3	33.7	33.4	35.7	31.7	30.2	---
Fineness 1/									
G.M.	4.89	4.27	4.09	4.57	4.16	4.40	4.50	3.90	3.92
S.M.	4.44	4.08	4.09	4.60	4.43	4.20	4.32	4.02	3.94
M.	4.45	4.13	3.78	4.21	4.00	3.81	4.12	3.86	3.85
S.L.M.	4.32	4.06	4.11	4.43	3.79	3.83	4.04	3.94	---
Immaturity (%)									
G.M.	25.4	28.6	27.6	24.3	26.3	25.0	23.6	24.5	28.7
S.M.	24.9	26.3	26.7	23.4	26.6	26.7	29.3	25.4	27.9
M.	26.0	26.9	23.2	28.7	27.7	26.9	27.0	27.5	27.2
S.L.M.	27.5	28.3	25.3	28.7	30.4	23.9	31.2	27.8	---
Chandler strength 2/									
G.M.	77.8	77.0	74.3	79.4	76.3	74.6	80.2	74.7	77.6
S.M.	78.0	76.8	73.5	79.9	75.8	71.2	79.9	75.4	72.8
M.	76.0	77.1	74.9	78.4	74.7	74.9	77.3	73.2	72.0
S.L.M.	77.1	75.0	76.0	78.1	74.0	75.5	78.0	72.4	---

1/ Micrograms per inch.
2/ Thousand pounds per square inch.

and it may be concluded that in general the lots in this test were not abnormal in this respect.

(d) Strength. Chandler bundle strengths for the rain-grown cotton were on an average 4 to 5 percent above those for the irrigated cotton. This is probably a significant fact, since other things being equal, stronger-fibered cottons produce stronger yarns.

On an average the California lots were about 1 percent stronger than those from the Arizona-New Mexico-Texas area. This difference, of course, is too small to possess any great significance.

(2) Manufacturing tests. In tables 3 to 8 the data for the three sets of test lots, where available, for each grade and staple combination have been averaged and are presented as one figure. In some instances, as shown in table 1, data for only two lots or occasionally for only one lot were available. Except for waste data, the more important data have been summarized in table 14, which permits a comparison of the different properties.

(a) Manufacturing waste. The quantity of yarn obtained per pound of cotton varies inversely with the waste removed in manufacturing. Thus, a high proportion of waste tends to lower spinning utility. It has frequently been claimed that, grade for grade, irrigated cotton produces more waste than rain-grown cotton. This contention was only partially substantiated by these tests. (Table 3 and figure 2.)

For the two shorter staple lengths, 1-1/16 and 1-3/32 inches, the waste percentage was generally highest for Arizona-New Mexico-Texas cotton and lowest for rain-grown cotton, with California irrigated cotton falling between the two. The Delta cotton in these lengths yielded from 0.28 to 1.27 percent less waste than the Arizona-New Mexico-Texas cottons.

For the longer staple, 1-1/8 inches, the Delta cottons yielded more waste than the irrigated cottons, and the California irrigated cottons more than the Arizona-New Mexico-Texas cottons. The only exception to this generalization was cotton of the Strict Middling grade in which Delta 1-1/8 inch cotton yielded slightly less waste than the irrigated cottons. For the other three grades the Delta cottons yielded from 0.79 to 1.15 percent more waste than the Arizona-New Mexico-Texas cottons, and from 0.29 to 0.94 percent more than the California cottons.

Waste percentages for Delta cottons in the Good Middling, Strict Middling, and Middling grades were not materially different from the respective averages for large numbers of lots tested in the Service's laboratories over a period of years. The waste percentage for Strict Low Middling cotton was somewhat lower than the average

Table 3. - Manufacturing waste for irrigated and rain-grown cotton, crop of 1939 1/

Grade of cotton and kind of waste	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Good Middling									
Opener-breaker	1.00	1.10	1.16	1.34	.88	1.11	1.51	1.19	1.02
Finisher picker	.33	.40	.42	.56	.42	.41	.68	.38	.39
Card									
Flat strips	2.99	3.64	3.88	3.29	4.07	4.16	3.27	2.95	2.92
Cyl. & doffer strips	.67	.84	.86	.70	.94	.99	.69	.67	.68
Motes and fly	1.38	1.66	1.85	1.25	1.58	1.71	1.37	1.43	1.43
Sweepings	.09	.11	.09	.14	.09	.11	.17	.13	.10
Total	5.13	6.25	6.68	5.38	6.68	6.97	5.50	5.18	5.13
Picker and card	6.37	7.64	8.10	7.14	7.86	8.28	7.57	6.63	6.42
Strict Middling									
Opener-breaker	1.16	1.06	1.28	1.16	1.05	1.23	1.12	1.14	1.10
Finisher picker	.36	.38	.48	.37	.38	.45	.39	.34	.43
Card									
Flat strips	2.83	3.47	4.00	3.36	4.14	4.51	3.71	3.74	2.89
Cyl. & doffer strips	.65	.77	.91	.75	.94	1.01	.87	.90	.69
Motes and fly	1.49	1.71	1.98	1.53	1.71	1.93	1.41	1.52	1.50
Sweepings	.09	.09	.10	.12	.10	.12	.09	.12	.16
Total	5.06	6.04	6.99	5.76	6.89	7.57	6.08	6.28	5.24
Picker and card	6.49	7.36	8.61	7.12	8.14	9.02	7.41	7.54	6.62
Middling									
Opener-breaker	1.21	1.25	1.61	1.25	1.17	1.51	1.36	1.16	1.31
Finisher picker	.43	.41	.60	.52	.44	.56	.42	.42	.41
Card									
Flat strips	2.93	3.46	3.88	3.48	4.05	4.44	3.93	3.84	3.04
Cyl. & doffer strips	.65	.77	.94	.82	.95	.94	.98	.90	.71
Motes and fly	1.70	1.83	2.28	1.77	1.78	2.23	1.61	1.65	1.83
Sweepings	.10	.12	.09	.12	.10	.09	.11	.13	.09
Total	5.38	6.18	7.19	6.19	6.88	7.70	6.63	6.52	5.67
Picker and card	6.91	7.36	9.17	7.74	8.28	9.48	8.20	7.91	7.21
Strict Low Middling									
Opener-breaker	1.54	1.56	2.13	1.48	1.50	2.12	1.64	1.45	---
Finisher picker	.58	.53	.84	.57	.55	.79	.53	.53	---
Card									
Flat strips	2.96	3.55	3.94	3.81	4.11	3.07	4.06	3.89	---
Cyl. & doffer strips	.69	.82	.89	.86	.95	.90	1.03	.98	---
Motes and fly	1.93	2.03	2.86	1.95	1.92	3.68	1.78	1.77	---
Sweepings	.13	.09	.15	.10	.10	.18	.09	.10	---
Total	5.71	6.49	7.84	6.72	7.08	7.83	6.96	6.74	---
Picker and card	7.67	8.38	10.46	8.51	8.89	10.45	8.88	8.50	---

1/ Percentages are for visible waste, and are based on weight of cotton fed to each machine, except for total picker and card waste, which is based on weight fed to opener-breaker.

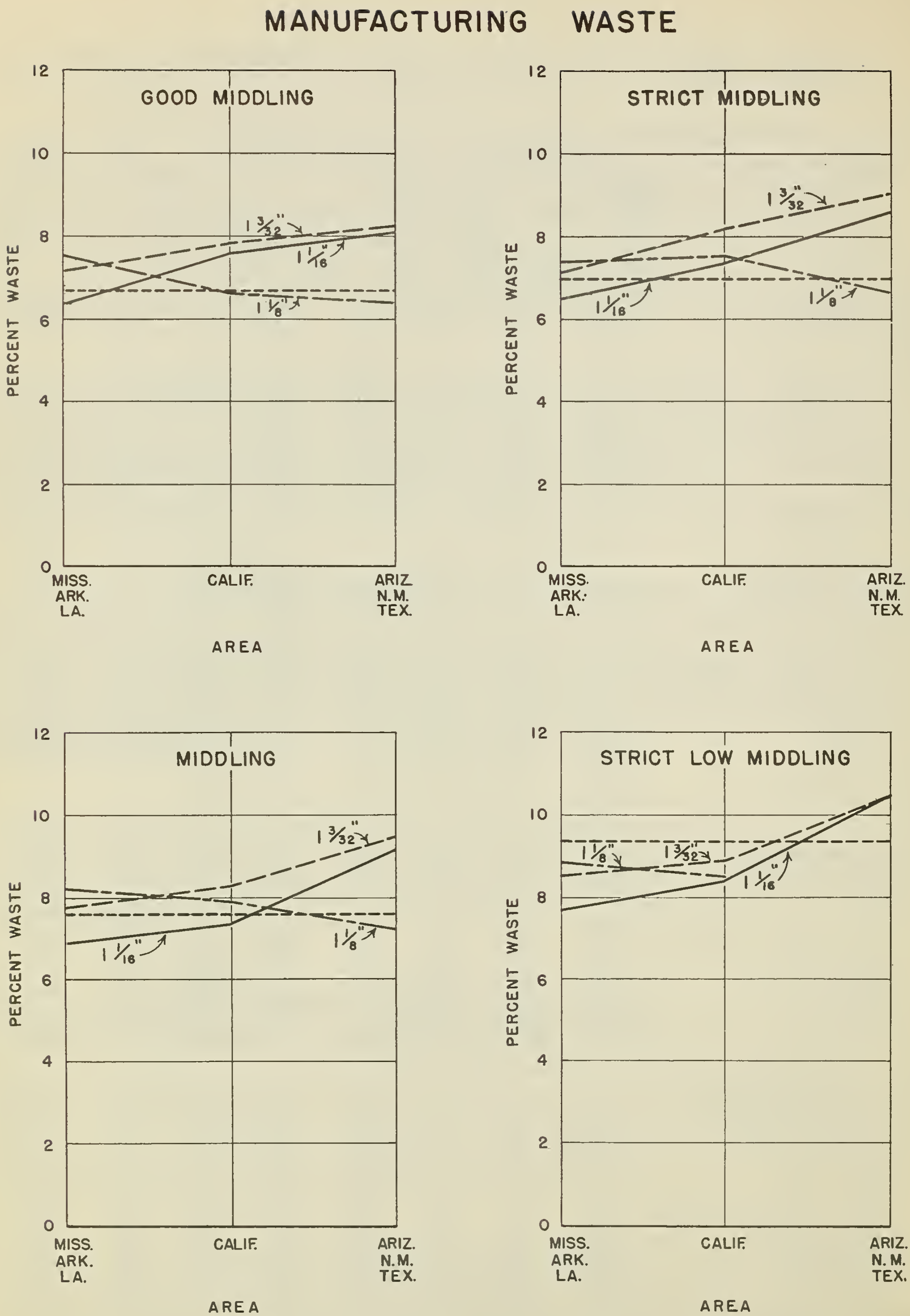

FIGURE 2.- TOTAL PICKER AND CARD WASTE. THE HORIZONTAL BROKEN LINES ARE AVERAGES FOR OTHER TESTS OF RELATIVELY LARGE NUMBERS OF AMERICAN UPLAND COTTONS OF THE SAME GRADES.

for upland cottons. These averages are believed to be fairly representative of waste percentages for upland cottons generally (figure 2).

California cottons of the three higher grades yielded slightly more waste than average in most cases, but in the Strict Low Middling grade, California cotton was found to be considerably less wasty than the average.

Arizona-New Mexico-Texas cottons yielded considerably higher waste percentages than the averages for all grades in the 1-1/16 and 1-3/32 inch lengths but lower percentages than the averages for the 1-1/8 inch length.

The importance of differences in waste percentages depends to a considerable extent on the price level of cotton. With cotton costing the mill 10¢ per pound a difference of 1 percent in waste between two cottons would mean that a mill could pay nearly 50¢ per bale more for the cotton having the smaller waste percentage than for the one having the larger. Of possibly even greater significance, however, is the fact that yarns and fabrics produced from the more wasty cotton usually contain more foreign matter particles, thus lowering their usefulness for many purposes. To remove this material would require more careful cleaning at an increased manufacturing cost and probably a significant increase in waste loss.

(b) Shirley analyzer waste. Waste removed by the opener, pickers, and card is, as shown in table 3, designated according to the machine or device which extracts it. In general, however, all this waste is composed either of fiber or of foreign matter which consists of leaf, motes, seed fragments, dirt, sand, etc. Foreign matter is particularly detrimental to spinning utility, not only because it represents a reduction in spinnable fiber per bale, but also because normally portions of it pass through the cleaning machines with the cotton and reduce the value of the yarns and fabrics. The more foreign matter present in the raw cotton, the greater will be the likelihood of objectionable quantities of it in the product. Thus, the quantity of foreign matter in a particular cotton is an important element of its quality.

The Shirley analyzer provides a quick means for determining the actual quantity of foreign matter in a small sample of cotton. The results obtained with this device on representative samples of each of the lots in this test are shown in table 4.

The lots of Delta and California cotton of comparable grade were quite similar with possibly two or three exceptions, as regards foreign matter content. Thus it may be concluded that the differences in manufacturing waste for these cottons (table 3) were due primarily to differences in the quantity of fiber removed from

Table 4. - Shirley analyzer waste for irrigated and rain-grown cotton, crop of 1939 1/

Grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
G.M.	2.57	3.28	3.18	2.81	2.78	3.09	3.00	3.13	3.24
S.M.	2.92	2.72	4.05	3.07	3.12	3.84	3.54	2.99	3.39
M.	3.57	3.46	4.98	3.78	3.79	4.50	4.00	3.75	4.50
S.L.M.	4.49	4.52	6.65	4.75	4.71	6.24	5.05	4.69	---

1/ Based on net weight of cotton fed to the machine.

them by the machines. On the other hand the Arizona-New Mexico-Texas cottons were noticeably higher in foreign matter content than the other two growths in 7 of the 11 grade and staple combinations. Since foreign matter as visually noted in cotton is a standardized element of grade, it is probable that the greater prevalence of foreign matter in the Arizona-New Mexico-Texas cottons was offset by better color or preparation.

(c) Skein strength of yarn. (Table 5 and figure 3.) The strength of yarn spun from a cotton is one of the principal indices of quality brought out by a spinning test. As a rule, stronger yarns mean greater economy in spinning and weaving, as well as fabrics or cords of greater strength and serviceability. As pointed out previously, one of the chief criticisms of irrigated cotton is that it produces weaker yarns than the rain-grown cotton.

Neither the Delta nor the California yarns were consistently stronger for all staple lengths and yarn counts. For the 1-1/16 inch length, the California yarns were slightly stronger except for 22s in which the differences were not consistent. For the 1-3/32 inch length there was little to choose between the two growths. In the case of the 1-1/8 inch cottons, the Delta yarns were slightly stronger in 10 of the 12 comparable cases. This may be due to the fact that the Delta samples were slightly longer and more uniform. (See table 2.)

Table 5. - Average skein strength of yarn spun from irrigated and rain-grown cotton, crop of 1939

Yarn count, and grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
22s									
G.M.	110.0	106.2	104.1	112.1	111.1	106.9	113.3	107.5	107.4
S.M.	108.7	107.2	102.7	114.2	110.6	104.9	115.3	110.3	103.5
M.	107.3	107.4	102.5	112.4	110.5	104.2	115.1	109.8	102.9
S.L.M.	104.4	107.8	100.9	111.5	110.5	106.4	111.1	111.1	---
44s									
G.M.	43.4	45.2	42.8	45.4	47.3	45.0	47.9	46.3	44.0
S.M.	43.9	45.4	42.5	46.6	46.8	44.1	48.9	45.2	43.1
M.	43.5	45.2	42.1	47.6	47.1	43.7	48.0	46.1	42.6
S.L.M.	43.3	45.7	42.6	47.2	47.4	45.1	47.5	45.8	---
60s									
G.M.	27.9	29.7	28.0	29.5	31.0	29.9	30.7	30.8	29.1
S.M.	28.5	29.5	28.0	30.4	30.9	29.0	31.6	30.7	29.5
M.	28.5	29.6	27.5	30.2	30.4	29.3	31.5	30.1	28.8
S.L.M.	28.1	30.4	26.8	30.5	30.8	29.1	31.5	30.5	---

Although individual differences were in some cases fairly large, on an average the differences in yarn strength between the Delta and California cottons were too small to possess any great importance (figure 3).

After averaging all counts of yarn for all grades and staples, the Arizona-New Mexico-Texas yarns are found to be about 5 percent weaker than the other two growths. Such a difference in yarn strength would be considered significant in the manufacture of many types of fabrics, as regards both the efficiency of large-scale weaving and the strength characteristics of fabrics used for mechanical purposes. It will be recalled that the fibers of this cotton were on an average slightly shorter, more irregular, and weaker than those of the other growths, and the somewhat weaker yarns are undoubtedly a reflection of these differences in fiber properties.

The count-strength product curves in figure 3 are for the averages of the three staple lengths included in this study. These curves illustrate clearly the yarn strength relationships of the three growths of cotton.

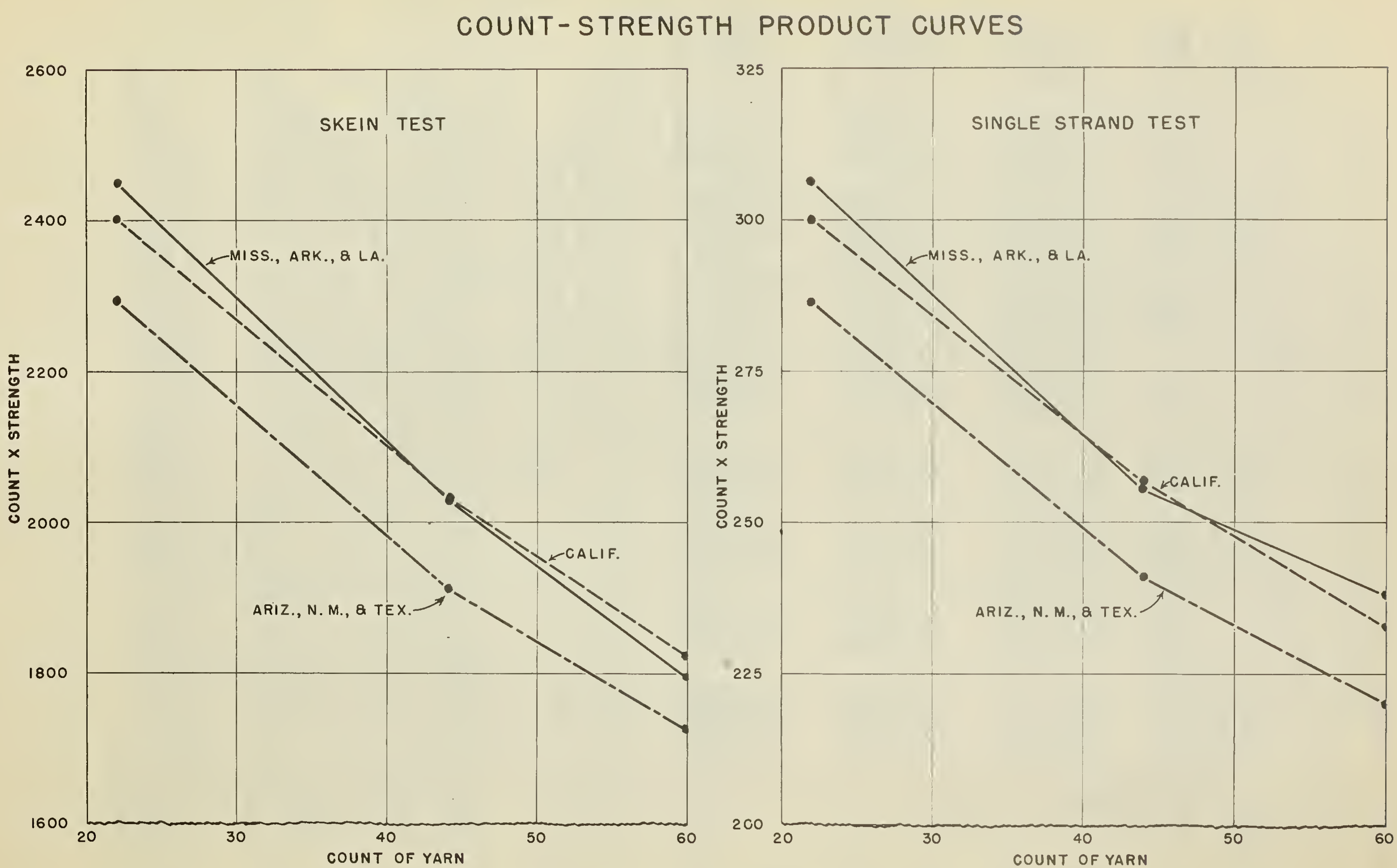

FIGURE 3.- COUNT-STRENGTH PRODUCT CURVES, BY TYPE OF TEST AND AREA. EACH PLOTTED POINT IS THE AVERAGE FOR ALL GRADES AND STAPLE LENGTHS FOR A PARTICULAR AREA.

(d) Single strand strength of yarn. (Table 6 and figure 3.) Because some manufacturers prefer to have yarn data in terms of single strand strength instead of skein strength, the results of this type of test are presented in detail in table 6. A comparison of these values with those for the skein strengths listed in table 5 shows a close agreement between the two types of test. Similarly, the count-strength product curves for the single strand data (figure 3) are seen to simulate those for the skein strengths to a high degree. The single-strand data may thus be considered to confirm the findings of the skein tests.

Table 6. - Average single strand strength of yarn spun from irrigated and rain-grown cotton, crop of 1939

Yarn count, and grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
22s									
G.M.	13.38	13.20	12.84	13.94	13.76	13.11	14.64	13.83	13.20
S.M.	13.42	13.33	12.80	14.29	14.10	12.91	14.45	13.99	12.87
M.	13.22	13.47	12.59	14.07	13.56	12.97	14.46	13.76	12.89
S.L.M.	12.92	13.27	13.05	14.00	13.47	13.61	14.16	13.74	---
44s									
G.M.	5.01	5.68	5.42	5.73	5.84	5.56	6.05	6.05	5.82
S.M.	5.66	5.76	5.23	5.75	5.82	5.49	6.23	5.90	5.47
M.	5.64	5.71	5.43	5.92	5.81	5.56	6.20	6.02	5.43
S.L.M.	5.55	5.91	5.47	5.83	5.79	5.39	6.00	5.94	---
60s									
G.M.	3.72	3.54	3.61	3.94	3.94	3.76	4.37	4.15	3.98
S.M.	3.70	3.67	3.49	3.96	3.96	3.74	4.33	4.07	3.85
M.	3.64	3.74	3.49	3.96	3.85	3.54	4.28	4.05	3.82
S.L.M.	3.68	3.74	3.39	3.94	3.87	3.68	4.13	4.09	---

(e) Cord strength and elongation. (Table 7.) The statement is frequently made by manufacturers of automobile tire cord that the strength relationships of a group of cottons differ according to whether the strengths of single yarns or of cords are considered. This fact has been substantiated in the laboratories of the Agricultural Marketing Service in other studies. For this reason, and because cotton of the staple lengths included in this study is used to a considerable extent in the manufacture of tire cord, it was thought that information on this subject would add to the value of this investigation.

Table 7. - Average strength and elongation of 23/5/3 tire cord made from irrigated and rain-grown cotton, crop of 1939

Cord property, and grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Strength									
G.M.	19.1	17.4	17.0	18.2	18.0	17.5	19.4	18.3	17.8
S.M.	18.6	17.5	16.7	18.6	17.8	17.1	18.7	18.9	17.3
M.	18.0	17.6	16.5	18.4	17.8	16.8	19.4	17.7	17.6
S.L.M.	17.8	17.5	16.7	18.4	17.8	17.8	17.9	18.0	---
Elongation at 10 lb.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
G.M.	14.1	14.0	13.6	13.6	14.2	12.9	13.2	12.8	11.3
S.M.	13.6	15.0	14.2	13.0	14.0	13.0	12.2	12.9	12.2
M.	13.1	14.5	14.3	13.2	13.9	13.6	12.0	12.6	12.7
S.L.M.	13.7	14.2	14.4	12.5	13.5	13.3	13.0	13.2	---

It is recognized that there are many constructions of tire cord. Naturally, in a test of this kind it is not feasible to attempt to manufacture and test these various constructions, and it was felt that a single type might indicate the relative utility of the three growths of cotton with respect to tire cord. The data in table 7 show the average strength and elongation (at a 10 pound load) for 23/5/3 cord.

The Delta cottons were found to produce the strongest cord in all cases but two. On an average, the cord from the Delta cotton was 5.8 percent stronger than that from the California, and 8.0 percent stronger than that from the Arizona-New Mexico-Texas cotton. The results of other studies have indicated that tire cord strengths are more sensitive to fiber strength differences than are single yarns. This is due possibly to the lesser opportunity for fiber slippage in a cord than in a single yarn. It can be shown from the data of this test that the cord is stronger in proportion to its size than the single yarn (as shown by single strand tests) is to its size. The averages of the Chandler bundle test results (listed in table 14) show that the Delta cotton had a 4.1 percent higher fiber strength than the California cotton, and a 5.4 percent higher strength than the Arizona-New Mexico-Texas cotton.

The cord strength differences reported here are large enough, on an average, to possess significance in the manufacture of tire cord.

It may be noted that there was a fairly uniform progressive increase in cord strength as longer staples were used. The effects of

grade differences were not consistent, although in some cases there appears to be a slight tendency for higher grades to produce stronger cord.

The percentage elongation of tire cord under a 10 pound load is a commonly used quality measurement. The data in table 7 do not show any marked differences in this respect among the different growths or grades. There is, however, a rather definite tendency toward lower elongation values for cord made from longer staples.

(f) Appearance of yarn. (Table 8.) One of the most significant differences among the cottons of this study is brought out in table 8. It is seen at once that the Delta yarns were for the most part distinctly better in appearance than those spun from the two irrigated growths. In 22s, the Delta yarns are on an average at least two-thirds of a grade better than the California yarns, and nearly one full grade better than the Arizona-New Mexico-Texas yarns. As will be shown later in this report, these differences in yarn appearance are reflected in the appearance of the grey, bleached, and dyed fabric.

Table 8. - Yarn appearance grade for irrigated and rain-grown cotton, crop of 1939

Yarn count and grade of cotton	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade	Grade
22s									
G.M.	A-	B-to C+	C	B+	B-to C+	C	B+	B+	B-
S.M.	B+	C+	C+	B+	C+	C	B toB+	C+	C+
M.	B+	C+	C+	B	C	C toC-	B	B-	B-
S.L.M.	B+	C+	C+	B-	C	C+	B-	C+	---
60s									
G.M.	B-	C	C-	B toB-	C-	C-	B	B-	C
S.M.	B	C	C-	B-	C-	C-	B-	C	C+
M.	B-	C	C-	B-	C	C-toD+	C+	C+	C
S.L.M.	B-	C	C-	C+	C	C-	C+	C+	---

Experience has shown that, to be considered quite satisfactory for most purposes from the standpoint of appearance, a 22s yarn should be equal to grade B plus or better, and that grade B is definitely the lowest grade that could be called generally acceptable. On such a basis, 10 of the 12 yarns spun from the rain-grown cotton would be acceptable. The remaining two, which were graded B minus, were both spun from cotton of Strict Low Middling grade. In contrast to this showing of the Delta cottons, only 1 of the 23 irrigated yarns was graded as high as B.

Of the Delta cottons, the 1-1/16 inch lots were on an average slightly better in appearance than the other two lengths, which were practically identical in most cases. For the irrigated cottons, on the other hand, the longest staple, 1-1/8 inches, gave slightly the best results, with the 1-1/16 inch length second and the 1-3/32 inch length third. As a result, it may be seen that the smallest differences in yarn appearance between growths was in the 1-1/8 inch group. In one case for 22s yarn and two cases for 60s, the California yarns were equal to the Delta yarns in appearance. The Delta yarns were, however, from one-third to one and two-thirds grades better than the Arizona-New Mexico-Texas yarns in every case.

There seemed to be a tendency for cottons of higher grade to produce yarns of better appearance, although the differences were small and in some cases yarns from lower grades were of better appearance.

In general, the 22s yarns were from a third to a full grade higher than the 60s, which is in line with findings of other tests made in the Service's laboratories.

(g) Strength of fabric. (Table 9 and figures 4, 5, and 6.) The tensile strengths of the fabric samples probably constitute the most important index as to the wearing quality of the fabrics and the suitability of the cottons for mechanical fabrics.

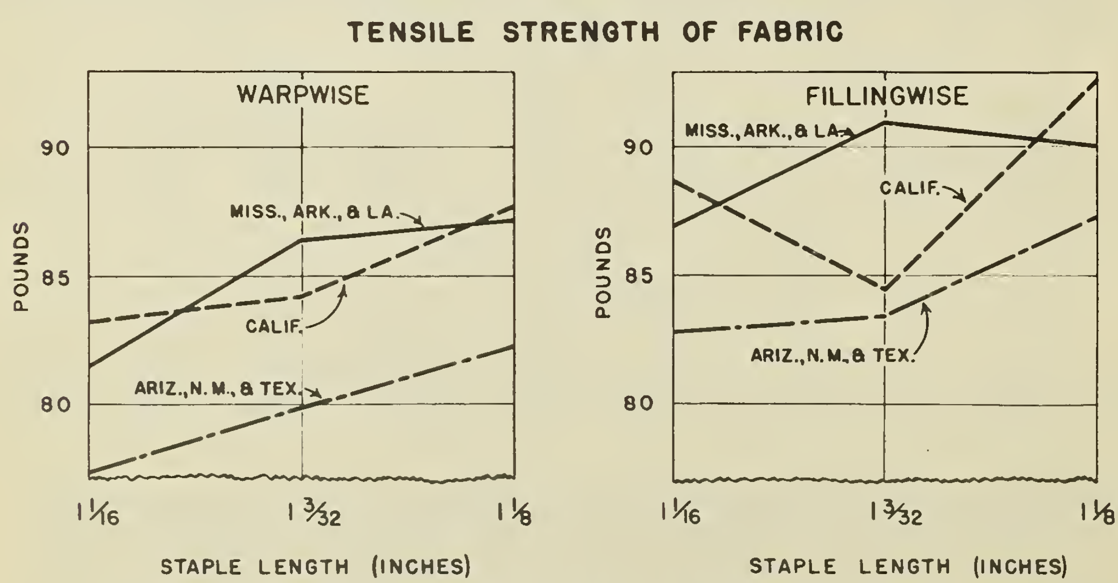

FIGURE 4 - WARPWISE AND FILLINGWISE TENSILE STRENGTHS OF FABRICS, BY AREA AND STAPLE LENGTH. EACH PLOTTED POINT IS THE AVERAGE FOR ALL GRADES INCLUDED IN THE STUDY.

In general the relationships of the different lots were quite similar to those of the 22s yarn (table 5), but some consistent differences can be seen. Both the warp and fillingwise strengths are highest for the California cotton in the 1-1/16 and 1-1/8 inch lengths, whereas the 1-3/32 inch samples were somewhat weaker than the Delta samples of this length. In strength of 22s yarn, the California cottons were about equal to the Delta cottons of 1-1/16 inch staple but slightly poorer than those of the 1-3/32 and 1-1/8 inch lengths.

The fabrics of both the Delta and California cottons were definitely superior in tensile strength to those of the Arizona-New Mexico-Texas cottons.

The charts in figure 4 show the average tensile strengths of the fabrics, and figure 5 shows the relationships of the fabrics with respect to bursting strength. These results are seen at once to follow the tensile strengths closely.

Tear tests are probably not so important as tensile and bursting strength tests as indices of fabric quality. There are, of course, specific uses in which resistance to tear is of primary importance. The data for this property of the fabrics are included here chiefly to provide as complete a picture as possible of the relative quality of the samples manufactured in this study. As shown in table 9 and figure 6, the warpwise tear resistance of the fabrics followed practically the same pattern as the fillingwise tensile of the fabric. (Figure 4.) In both cases it was the filling yarn that was being tested. In the case of the fillingwise tear test, however, the pattern differed somewhat from the warpwise tensile strengths. The fabrics from the 1-1/16 inch cottons averaged practically the same for the three growths, but those from the 1-3/32 and 1-1/8 inch staples gave considerably different results, with the California samples highest, and the Arizona-New Mexico-Texas samples the lowest.

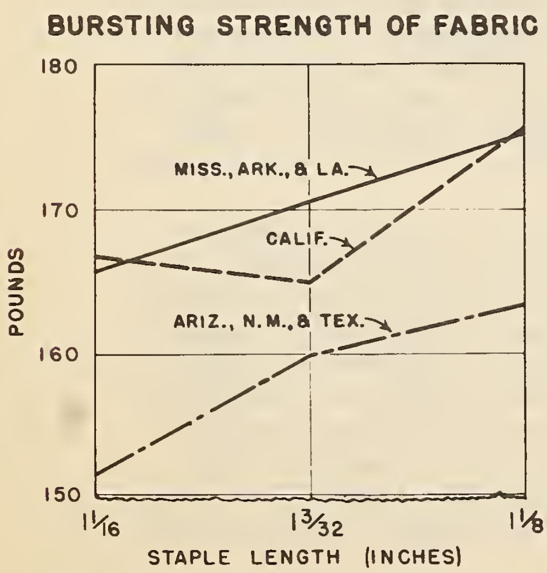

FIGURE 5 - BURSTING STRENGTH OF FABRICS BY AREA AND STAPLE LENGTH. EACH PLOTTED POINT IS THE AVERAGE FOR ALL GRADES INCLUDED IN THE STUDY.

(h) Appearance of unbleached fabric. As previously explained, one of the chief criticisms of irrigated cotton is that it produces a fabric of rougher, neppier appearance than does rain-grown cotton. Particular attention was given, therefore, to the relative appearance of the fabrics made in this study.

TEARING STRENGTH OF FABRIC

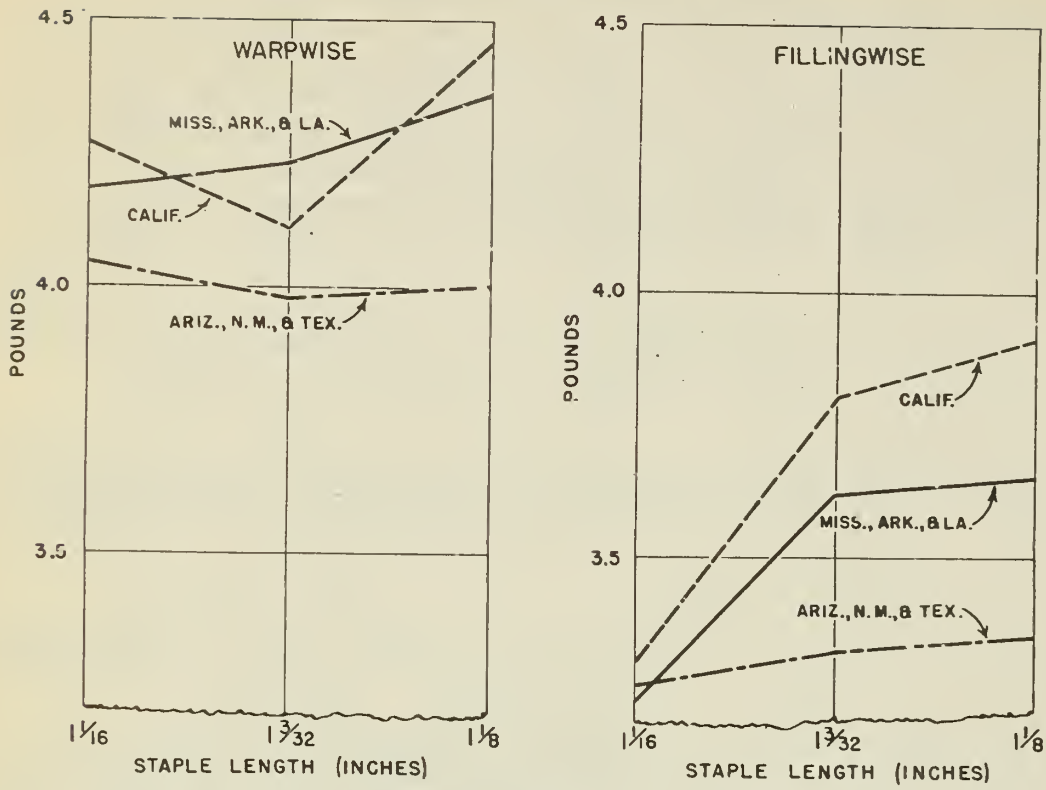

FIGURE 6. - TEARING STRENGTH, WARPWISE AND FILLINGWISE, OF FABRICS BY AREA AND STAPLE LENGTH. EACH PLOTTED POINT IS THE AVERAGE FOR ALL GRADES INCLUDED IN THE STUDY.

The samples of unbleached fabric of a particular grade and staple length were compared for the three growths by viewing them when held against the daylight. To provide permanent records of the appearance under this condition, each sample was photographed in actual size, with the use of transmitted light. With such a light, the imperfections in the fabric are considerably accentuated. In a report of this kind it is obviously not feasible to include the photographs of all 35 fabric samples. Reproductions of three photographs showing a fairly typical relationship have been included (figure 7). These particular samples were made from Strict Middling, 1-1/16 inch cotton.

The three pictures show a rather distinct difference between the Delta fabric and the samples made from the irrigated cotton. It should be remembered that the imperfections are accentuated in these illustrations, and that all the samples possess a much better appearance when viewed normally, with reflected light. The darker specks are particles of foreign matter adhering to the surface of the cloth. The lighter, less distinct specks are either neps or foreign matter particles on the opposite side of the sample. It is seen that the Delta fabric is freer of both the dark and the light specks, and that the yarns are more uniform; that is, they contain fewer thick-and-thin places.

These particular samples typify the differences found in most of the 35 samples. It is important to note, however, that the differences were slight for the samples made from the 1-1/8 inch

MISSISSIPPI, ARKANSAS AND LOUISIANA

CALIFORNIA

ARIZONA, NEW MEXICO AND TEXAS

Figure 7. -- Reproductions of actual-size photographs of unbleached sheeting. The photographs were made with transmitted light and illustrate typical differences in fabric appearance for the 3 growths. These samples were made from Strict Middling cotton of 1-1/16 inch staple length.

Table 9. - Results of tests of sheeting made from irrigated and rain-grown cotton, crop of 1939 1/

Test and grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Tensile (warp)									
G.M.	83.6	81.0	79.6	86.3	86.0	81.2	87.4	85.8	82.7
S.M.	82.6	83.2	76.6	86.0	86.4	79.5	88.2	89.0	82.3
M.	80.0	82.8	76.1	85.7	83.5	76.9	84.6	89.4	81.5
S.L.M.	79.9	85.8	77.0	87.2	80.9	82.1	88.1	86.7	---
Tensile (filling)									
G.M.	86.7	88.8	85.4	88.0	86.0	81.6	89.7	92.5	85.0
S.M.	90.3	90.7	80.8	91.0	83.2	82.9	89.2	95.4	87.0
M.	86.0	86.5	80.7	91.8	84.4	81.0	88.5	93.7	89.7
S.L.M.	84.4	88.5	83.8	92.8	84.4	81.0	92.5	87.9	---
Bursting strength									
G.M.	172	165	154	170	168	163	177	171	166
S.M.	168	166	151	170	163	159	179	184	161
M.	162	168	151	170	164	157	169	180	163
S.L.M.	160	167	149	172	164	160	177	168	---
Tear (warp)									
G.M.	4.23	4.17	4.11	4.28	3.99	4.28	4.80	4.43	4.13
S.M.	4.33	4.05	4.12	4.26	3.99	3.73	4.17	4.75	3.79
M.	4.15	4.30	3.92	4.28	4.16	3.85	4.25	4.31	4.10
S.L.M.	4.01	4.57	4.01	4.06	4.29	4.06	4.20	4.37	---
Tear (filling)									
G.M.	3.44	3.47	3.20	3.69	3.34	3.43	3.98	3.93	3.37
S.M.	3.25	3.35	3.28	4.14	3.88	3.17	3.73	3.95	3.30
M.	3.26	3.22	3.25	3.34	4.10	3.36	3.54	4.09	3.39
S.L.M.	2.91	3.15	3.25	3.29	3.89	3.36	3.36	3.71	---

1/ 68 x 72 construction, 4.90 oz. per square yard.

cotton, and that in one or two cases the irrigated cotton was equal or possibly superior in fabric appearance to the Delta samples. For example, the fabric made from Strict Low Middling, 1-1/8 inch cotton from California was freer of neps and irregularities than the Delta fabric made from the same grade and staple. This was due primarily, however, to the rather poor appearance of the latter sample.

The fabric samples were graded for fabric appearance, and 10 out of the 12 Delta samples were readily picked out of each group of three as being best.

The differences in appearance of California and Arizona-New Mexico-Texas cloth samples were not consistent. In some pairs of samples the California fabric was slightly better; in others, the Arizona-New Mexico-Texas samples had a better appearance; in still others, there was no choice between the two.

Most unbleached fabrics made from carded yarns contain some particles of foreign matter, such as leaf or seed coat fragments, on their surfaces. When such cloths are bleached, practically all this material is either dissolved or washed away, so that in limited quantities the particles are not considered detrimental. But when cloth is to be sold "in the grey" it is important that it be as free as possible from such particles in order that it may have an attractive appearance.

The average number of foreign matter particles per square inch is shown in table 10 for each of the fabric samples of this test. In most cases the Delta samples contained fewer foreign matter particles per square inch of surface than did the irrigated samples. In the 1-1/8 inch group, however, this was not true in all cases. For the Delta fabrics of this group a slightly higher figure than that for the California lots was found in the case of the Strict Middling and the Strict Low Middling. For Middling the Delta was practically the same as the Arizona-New Mexico-Texas cotton in this respect.

In nearly every instance the fabrics from cotton of lower grade contained a greater number of particles than those from higher grades, even though more manufacturing waste had been removed from the cotton of lower grade.

(i) Bleaching and dyeing properties. 2/ It is usual for the color of raw cotton to vary with grade, the lower grades becoming

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2/ Acknowledgment is made of the service and advice rendered by Professors Joseph Lindsay and M. L. Huckabee of the faculty of the School of Textiles, Clemson Agricultural College, in bleaching and dyeing the fabrics in this study. Acknowledgment also is made to Dr. K. S. Gibson of the National Bureau of Standards for making the spectrophotometric measurements possible. The measurements were made by H. J. Keegan, National Bureau of Standards, and Dorothy Nickerson, Color Technologist, Agricultural Marketing Service.

Table 10. - Average number of particles of foreign matter per square inch of cloth made from irrigated and rain-grown cotton, crop of 1939

Grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	No.	No.	No.	No.	No.	No.	No.	No.	No.
G.M.	1.11	2.46	3.17	1.80	2.74	3.33	1.73	2.93	2.11
S.M.	1.38	3.09	3.20	2.02	3.04	3.39	2.46	2.28	2.57
M.	2.02	3.71	3.08	2.19	4.38	3.61	2.98	3.94	2.97
S.L.M.	2.76	4.17	4.10	3.27	4.23	4.49	3.53	3.24	---

progressively darker and dirtier, or more spotted than the higher grades. It is also true, however, that for cottons commercially graded against the official standards there is often little or no color difference in grades Middling and above, except perhaps a tendency for cotton of the higher grades to be slightly creamier than cotton of the lower grades from the same areas.

In this study, there were greater color differences in fabrics between grades of rain-grown cotton than between similar grades of cotton grown under irrigation. This is borne out by reference to table 11 under the columns designated as "Unbleached." The figures, which relate to percentage light reflectance at a single wavelength, indicate little difference for the Delta fabrics in the brightness level of the two higher grades, but grades Middling and Strict Low Middling were definitely and progressively lower in brightness. The unbleached fabric samples made from Arizona-New Mexico-Texas cotton showed little difference in brightness for the three higher grades, but the Strict Low Middling was distinctly lower in brightness. The California samples were all on a higher brightness level and showed rather small but regular brightness differences, Good Middling being the highest and Strict Low Middling, the lowest.

A peculiarity is observed when a comparison is made of samples manufactured from the different staple lengths. The average brightness (at the wavelength selected) of the unbleached fabric from each area increased slightly with increase in staple length. The reason for this is not clear, however.

A comparison of the bleached and dyed fabrics with the corresponding unbleached samples indicates that grade differences in the raw

Table 11. - Percentage of light reflectance 1/ at single wavelength, for fabric samples made from irrigated and rain-grown cotton, crop of 1939

Area and grade	Unbleached 2/				Bleached 2/				Blue 3/				Black 2/			
	1-1/16 inches	1-3/32 inches	1-1/8 inches	Av.	1-1/16 inches	1-3/32 inches	1-1/8 inches	Av.	1-1/16 inches	1-3/32 inches	1-1/8 inches	Av.	1-1/16 inches	1-3/32 inches	1-1/8 inches	Av.
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Miss.,Ark.,La.																
G.M.	76.0	75.5	76.3	75.9	83.2	83.4	83.3	83.3	31.6	31.5	32.5	31.9	02.44	02.52	02.55	02.50
S.M.	76.2	76.2	76.0	76.1	83.2	83.6	83.3	83.4	32.8	31.7	31.9	32.1	02.54	02.49	02.60	02.54
M.	73.5	74.8	75.3	74.5	82.8	82.8	83.4	83.0	32.9	32.2	31.9	32.3	02.59	02.64	02.64	02.62
S.L.M.	71.0	72.4	73.6	72.3	82.3	83.5	83.3	83.0	32.8	32.9	32.3	32.7	02.62	02.65	02.70	02.66
Average	74.2	74.7	75.3	74.7	82.9	83.3	83.3	83.2	32.5	32.1	32.2	32.2	02.55	02.58	02.62	02.58
Calif.																
G.M.	76.5	76.6	77.5	76.9	83.6	84.0	84.3	84.0	33.1	32.8	32.3	32.8	[illegible]	02.71	02.66	02.67
S.M.	75.7	76.6	76.8	76.4	83.7	84.2	83.5	83.8	33.6	32.6	32.7	33.0	02.62	02.65	02.64	02.64
M.	76.0	75.9	76.5	76.1	83.3	83.6	83.7	83.5	32.5	33.0	33.3	32.9	02.70	02.63	02.65	02.66
S.L.M.	75.4	75.4	76.1	75.6	83.9	83.9	83.7	83.8	33.2	33.0	32.7	33.0	02.79	02.63	02.70	02.71
Average	75.9	76.1	76.7	76.2	83.6	83.9	83.8	83.8	33.1	32.8	32.8	32.9	02.69	02.66	02.66	02.67
Ariz.,N.M.,Tex.																
G.M.	74.7	76.2	76.1	75.7	83.8	84.8	83.6	84.1	32.9	33.0	33.2	33.1	02.73	02.80	02.66	02.73
S.M.	75.3	75.6	76.9	75.9	84.0	84.0	84.1	84.0	33.1	32.4	32.4	32.6	02.75	02.68	02.79	02.74
M.	75.7	76.3	76.1	76.0	84.3	85.0	83.3	84.2	33.8	33.1	33.4	33.4	02.79	02.70	02.82	02.77
S.L.M.	74.1	74.4	---	74.2	83.5	83.8	---	83.6	33.5	32.9	---	33.2	02.65	02.75	---	02.70
Average	75.0	75.6	76.4	75.4	83.9	84.4	83.7	84.0	33.3	32.8	33.0	33.1	02.73	02.73	02.76	02.74

1/ Relative to MgO, uncorrected. B. S. Test 4311-350/41
2/ Equal to 580 mµ
3/ Equal to 460 mµ

cotton were partially lost in the bleaching process, and wholly masked when dyed. Samples that showed the greatest difference in color in the original series of samples did not show extreme differences in the bleached and dyed series. Instead, samples that differed less than the extremes before bleaching, showed greater differences after bleaching and dyeing. This seems to indicate that properties of the cottons not evidenced by color of the raw stock are responsible for differences in bleaching and dyeing qualities.

The Delta cottons did not bleach quite so white as the Arizona-New Mexico-Texas cottons, but they seemed to absorb more dye. It is possible that the greater number of undyed neps in the latter, to be discussed below, may have contributed to this result. Although in the unbleached fabric the California samples were the brightest cottons in the series, on the whole they were no so bright as the Arizona-New Mexico-Texas cottons after bleaching and dyeing.

In general this study bears out the statement that irrigated and rain-grown cottons do not absorb dye to the same degree. In fact, the differences observed were large enough in many cases to cause serious trouble if yarns from irrigated and rain-grown growths were mixed indiscriminately in the warp or filling of fabric that is to be dyed, as such a practice would be almost sure to cause streakiness in the finished fabrics. This finding is not, of course, a reflection against either irrigated or rain-grown cotton.

The count of the number of neps visible on the surface of the dyed fabrics constituted an important part of the study. One of the most frequently heard criticisms of irrigated cotton is that cloth made from it is relatively neppy and that the neps do not dye readily, with the result that the cloth presents a "speckled" appearance.

The 35 fabric samples that had been dyed with the 1 percent solution of Solantine Black L dye were subjected to a careful inspection for neps, with the use of a wide-field microscope. 3/ Nep counts were made on 50 square-inch areas for each sample, and as they were counted they were classified according to whether they were lighter in color than the background or the same color as the background. The results of this test are shown in table 12.

The Delta fabrics were found to contain on an average from 2.36 to 6.22 neps per square inch, with a tendency toward more neps for longer staples and lower grades. The California samples averaged

3/ The nep counts for these fabric samples were made by Dr. Norma L. Pearson, Associate Cotton Technologist, Bureau of Plant Industry, U. S. Department of Agriculture.

Table 12. - Average number of neps per square inch of fabric made from irrigated and rain-grown cotton, crop of 1939

Grade and area	Neps lighter than background			Neps same color as background			Total neps		
	1-1/16 inches	1-3/32 inches	1-1/8 inches	1-1/16 inches	1-3/32 inches	1-1/8 inches	1-1/16 inches	1-3/32 inches	1-1/8 inches
	No.	No.	No.	No.	No.	No.	No.	No.	No.
G.M.									
Miss.,Ark.,La.	1.46	2.04	1.86	.90	.90	1.44	2.36	2.94	3.10
Calif.	5.04	3.86	2.60	1.82	1.82	2.42	8.22	5.68	5.02
Ariz.,N.M.,Tex.	4.04	4.76	2.34	4.00	4.46	2.38	8.04	9.22	4.72
S.M.									
Miss.,Ark.,La.	1.86	2.40	2.10	1.22	1.02	1.66	3.08	3.42	3.76
Calif.	3.70	3.82	2.36	3.10	2.74	1.98	6.80	6.56	4.34
Ariz.,N.M.,Tex.	3.74	4.28	3.30	3.60	3.96	1.94	7.34	8.24	5.24
M.									
Miss.,Ark.,La.	1.78	2.66	2.68	1.34	1.42	1.16	3.12	4.08	3.84
Calif.	3.70	3.96	1.98	2.74	2.84	2.18	6.44	6.80	4.16
Ariz.,N.M.,Tex.	4.68	3.14	3.12	3.62	3.50	2.44	8.30	6.64	5.56
S.L.M.									
Miss.,Ark.,La.	1.90	2.98	4.00	.98	1.46	2.22	2.88	4.44	6.22
Calif.	4.08	3.86	1.86	2.64	2.26	1.82	6.72	6.12	3.68
Ariz.,N.M.,Tex	3.04	5.48	---	2.64	5.44	---	5.68	10.92	---

from 3.68 to 8.22 neps per square inch, and it is surprising to see that the relationships in this respect for the different grades and staples were entirely different from those of the Delta cotton. In the California samples, as the staple length became longer, fewer neps were observed, and if any trend is present with respect to grade it is in the direction of fewer neps with lower grade. For the Arizona-New Mexico-Texas samples, a range of from 4.72 to 10.92 neps per square inch was found. The influence of grade and staple length is not very distinct, but there is a tendency toward more neps for the intermediate length (1-3/32 inches) and fewer for the longest length (1-1/8 inches).

Obviously, light-colored neps are more objectionable than those that have absorbed dye to the same degree as the fabric. Although from 62 to 66 percent of the neps in the Delta fabric were lighter than the cloth as compared with from 51 to 60 percent of the neps in the fabric made from irrigated cotton, the latter actually contained more light-colored neps per square inch in all but two cases.

A careful visual comparison of the bleached and dyed fabric samples was made, and with very few exceptions it was easy to pick out the Delta specimens because of their better appearance--smoother yarns, greater freedom from neps, and, in the case of the dyed samples, slightly darker color. The differences were more distinct than those between unbleached samples, even though essentially all foreign matter particles were removed in the bleaching process. Differences between the two irrigated growths, as regards the appearance of the bleached and dyed samples, were not consistent. The Arizona-New Mexico-Texas samples were considered slightly preferable to the California samples in about half the cases, and in the other half, the reverse was true.

(j) General manufacturing characteristics. An examination of the detailed laboratory notes describing the appearance and manufacturing efficiency of each test lot on each machine reveals no important differences in these respects among the three growths studied. For the most part the appearance of the card and drawing webs as regards smoothness was satisfactory, and the quantity of flyings and clearer waste on all the machines was not outstandingly high. Some slight differences in quantity of flyings and clearer waste were observed, but these were not characteristic of any one growth. The same was true of the appearance of the rovings.

No difficulty was experienced during the spinning, twisting, warp preparation, or weaving of these cottons, except that rates of end breakage during the spinning of the finer counts of yarn were excessive. This will be discussed in detail. A frequently heard criticism of irrigated cotton is that it is susceptible to roller lapping on several of the machines. During this test there was no tendency on the part of any of the lots toward the formation of roller laps.

To summarize the observations on general manufacturing characteristics, it may be said that the three growths showed no outstanding differences in this respect, and that none of the lots of irrigated cotton exhibited any of the objectionable machining faults frequently attributed to this cotton.

The rate of end breakage during spinning constitutes an important and frequently used measure of the manufacturing efficiency of cotton. It is usually computed in terms of ends down per hundred or per thousand spindles per hour. To possess greatest significance, such a test must involve a rather large number of spindles operated over a period of several days. For obvious reasons this could not be done in the present study, in which only a small quantity of yarn was spun on a few spindles. Nevertheless the end breakages occurring

during this experimental spinning were recorded and the rate of end breakage per hundred spindles per hour computed for each lot with the thought that the data might serve as rough indices of spinning efficiency. The results are shown in table 13.

There is no definite dividing line between satisfactory and unsatisfactory spinning, as much depends upon the number of spindles per operative, the count of yarn being spun, and the quality of the goods being made. However, for purposes of this investigation a limit of, say, 5 ends down per 100 spindles per hour may be set, above which the cotton may reasonably be considered unsatisfactory for the particular count spun.

On such a basis only two cottons, both of them from the Arizona-New Mexico-Texas area, were found to show excessive spinning end breakage for 22s. Six cottons, half of them of the Delta growth, exceeded the 5-end rate for 44s. Only four cottons, three of which were of irrigated growth, were found to yield satisfactorily low rates of end breakage for 60s. This is not surprising, however, as 60s are above the generally accepted range for even 1-1/8 inch staple.

On an average, the California lots were found to break less frequently than the other two growths, except for the 1-1/8 inch lots where the advantage was with the Delta cotton in four of the five cases involving excessive breakage.

Table 13. - Spinning end breakage per 100 spindles per hour, for irrigated and rain-grown cotton, crop of 1939

Yarn count, and grade	1-1/16 inches			1-3/32 inches			1-1/8 inches		
	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.	Miss. Ark. La.	Calif.	Ariz. N. M. Tex.
	No.	No.	No.	No.	No.	No.	No.	No.	No.
22s									
G.M.	0	0	8.9	0	0	0	0	0	0
S.M.	0	0	0	4.4	0	0	0	0	0
M.	0	0	0	0	0	0	0	0	0
S.L.M.	0	0	0	0	0	18.5	0	0	---
44s									
G.M.	0	0	0	8.3	0	2.8	0	0	15.8
S.M.	0	0	2.8	5.6	5.6	2.8	13.9	0	0
M.	3.0	0	0	2.8	0	0	0	0	0
S.L.M.	2.8	0	0	2.8	0	8.3	0	2.6	---
60s									
G.M.	60.0	25.7	38.6	12.6	2.1	16.6	8.3	16.6	34.3
S.M.	20.0	10.0	40.0	9.8	7.0	30.0	2.1	17.9	8.6
M.	22.9	11.4	45.7	12.7	5.7	27.9	6.3	7.1	12.4
S.L.M.	27.1	4.3	4.3	9.9	5.5	8.6	0	7.1	---

Table 14. - Summary of fiber, yarn, and fabric tests, irrigated and rain-grown cotton, crop of 1939

Area	Staple length (inches)	Upper quartile length (inches): Av. each length	Upper quartile length (inches): Av. all lengths	Mean length (inches): Av. each length	Mean length (inches): Av. all lengths	Coef. var. length (%): Av. each length	Coef. var. length (%): Av. all lengths	Weight per inch (ugs.): Av. each length	Weight per inch (ugs.): Av. all lengths	Thin-walled fibers (%): Av. each length	Thin-walled fibers (%): Av. all lengths	Bundle strength (M-lb./in.^{2}): Av. each length	Bundle strength (M-lb./in.^{2}): Av. all lengths
Miss., Ark., La.	1-1/16	1.216		1.001		30.7		4.52		26.0		77.2	
	1-3/32	1.253	1.260	1.035	1.040	30.4	30.3	4.45	4.41	26.3	26.7	79.0	78.3
	1-1/8	1.310		1.084		29.7		4.24		27.8		78.8	
Calif.	1-1/16	1.230		.986		33.9		4.14		27.5		76.5	
	1-3/32	1.250	1.251	1.008	1.014	33.4	32.7	4.10	4.05	27.8	27.2	75.2	75.2
	1-1/8	1.272		1.047		30.8		3.93		26.3		73.9	
Ariz., N. M., Tex.	1-1/16	1.210		.959		35.1		4.02		25.7		74.7	
	1-3/32	1.255	1.247	.999	.995	34.2	34.2	4.06	4.00	25.6	26.3	74.0	74.3
	1-1/8	1.286		1.037		32.8		3.90		27.9		74.1	

Area	Staple length (inches)	Skein strength 22s (lb.): Av. each length	Skein strength 22s (lb.): Av. all lengths	Skein strength 44s (lb.): Av. each length	Skein strength 44s (lb.): Av. all lengths	Skein strength 60s (lb.): Av. each length	Skein strength 60s (lb.): Av. all lengths	Single strand strength 22s (oz.): Av. each length	Single strand strength 22s (oz.): Av. all lengths	Single strand strength 44s (oz.): Av. each length	Single strand strength 44s (oz.): Av. all lengths	Single strand strength 60s (oz.): Av. each length	Single strand strength 60s (oz.): Av. all lengths
Miss., Ark., La.	1-1/16	107.6		45.3		28.2		13.24		5.46		3.68	
	1-3/32	112.6	111.3	46.7	46.1	30.2	29.9	14.08	13.91	5.81	5.80	3.95	3.97
	1-1/8	113.7		48.1		31.3		14.43		6.12		4.28	
Calif.	1-1/16	107.2		45.4		29.8		13.32		5.76		3.67	
	1-3/32	110.7	109.2	47.2	46.1	30.8	30.4	13.72	13.62	5.82	5.85	3.90	3.89
	1-1/8	109.7		45.8		30.5		13.83		5.98		4.09	
Ariz., N. M., Tex.	1-1/16	102.6		42.5		27.6		12.82		5.39		3.50	
	1-3/32	105.6	104.2	44.5	43.4	29.3	28.7	13.15	12.98	5.50	5.48	3.68	3.67
	1-1/8	104.6		43.2		29.5		12.99		5.57		3.88	

Area	Staple length (inches)	Tire cord strength (lb.): Av. each length	Tire cord strength (lb.): Av. all lengths	Grab test, warp (lb.): Av. each length	Grab test, warp (lb.): Av. all lengths	Grab test, fill. (lb.): Av. each length	Grab test, fill. (lb.): Av. all lengths	Bursting strength (lb.): Av. each length	Bursting strength (lb.): Av. all lengths	Tear test, warp (lb.): Av. each length	Tear test, warp (lb.): Av. all lengths	Tear test, fill. (lb.): Av. each length	Tear test, fill. (lb.): Av. all lengths
Miss., Ark., La.	1-1/16	18.38		81.5		86.8		165.5		4.18		3.22	
	1-3/32	18.40	18.54	86.3	85.0	90.9	89.2	170.5	170.5	4.22	4.25	3.62	3.49
	1-1/8	18.85		87.1		90.0		175.5		4.36		3.65	
Calif.	1-1/16	17.50		83.2		88.6		166.5		4.27		3.30	
	1-3/32	17.85	17.86	84.2	85.0	84.5	88.5	164.8	169.0	4.11	4.28	3.80	3.67
	1-1/8	18.22		87.7		92.4		175.8		4.46		3.92	
Ariz., N. M., Tex.	1-1/16	16.72		77.3		82.7		151.2		4.04		3.24	
	1-3/32	17.30	17.16	79.9	79.6	83.3	84.2	159.8	158.1	3.98	4.01	3.33	3.31
	1-1/8	17.57		82.2		87.2		163.3		4.01		3.35	

SUMMARY

The relative quality of irrigated and rain-grown American upland cotton has been the subject of controversy among cotton producers, shippers, and consumers for a number of years. Frequent complaints regarding the manufacturing quality of irrigated cotton have made it imperative that an unbiased, carefully conducted series of tests be made to obtain a true comparison of these cottons. It was the purpose of this study to determine, through detailed fiber and manufacturing tests, the nature and extent of the differences, if such exist, between commercially grown irrigated and rain-grown cotton of certain grade and staple combinations produced during the 1939 season.

Composite test lots each containing about 250 bale samples, or about 50 pounds, were obtained, to the extent of the supply available, for 12 grade and staple combinations from each of three general areas. The areas represented were (1) the Delta, or Mississippi, Arkansas, and Louisiana; (2) the cotton-growing districts of California; and (3) the cotton-growing districts of Arizona, New Mexico, and west Texas (El Paso area). Cotton classed as Good Middling, Strict Middling, Middling, and Strict Low Middling of each of three staple lengths, 1-1/16, 1-3/32, and 1-1/8 inches, was selected at the classing offices of the Agricultural Marketing Service at Memphis, Tenn., Bakersfield, Calif., and El Paso, Texas, for the tests. As far as possible, triplicate test lots were obtained.

In all, 81 test lots composed of about 20,000 bale samples were drawn from a total supply of about 130,000 samples in such a manner as to ensure a representative cross-section of the available supply of cotton. Each test lot was subjected to the following fiber tests: Length and length variability; fineness, in terms of weight per inch; immaturity, measured in terms of the percentage of thin-walled fibers; and bundle strength in terms of 1000 pounds per square inch of cross-section.

In the manufacturing laboratory, the cottons were subjected to tests as follows: Manufacturing waste; Shirley analyzer waste; skein and single-strand yarn strengths; yarn appearance; tire cord strength and elongation; tensile, bursting, and tearing strength of sheeting; appearance of fabric; bleaching and dyeing properties of fabric; and general manufacturing characteristics.

The following statements summarize the more important findings of this study:

There was a fairly close agreement in upper quartile fiber lengths of comparable staple lengths among the three growths, except

that the Delta cottonswhich were classed as 1-1/8 inches were about 0.03 inch longer than the irrigated cottons. The Delta cottons were the most uniform in fiber length, with the California cottons second. Hence, the mean fiber lengths of the irrigated cottons were slightly shorter.

The Delta cottons were slightly coarser or heavier in fiber weight per inch, with the California and Arizona-New Mexico-Texas cotton on an average approximately equal in this respect.

There were no important differences among the three growths in percentage of thin-walled fibers.

The Delta cottons averaged 4 to 5 percent stronger in fiber bundle strength than the irrigated cottons. The California cottons were about 1 percent stronger than the Arizona-New Mexico-Texas cottons.

In total manufacturing waste, the relationships among the three growths differed somewhat for the three staple lengths. In the two shorter lengths, the Delta cottons were consistently less wasty, yielding from 0.38 to 1.27 percent, or an average of 0.75 percent, less picker and card waste than the California cottons, and from 1.14 to 2.79 percent, or an average of 1.95 percent, less waste than the Arizona-New Mexico-Texas cottons. For the 1-1/8 inch cottons, the order was reversed, although the differences were considerably smaller.

Shirley analyzer tests showed that, grade for grade, the Delta and California cottons contained nearly the same relative quantity of foreign matter, but that the Arizona-New Mexico-Texas cottons were significantly higher in foreign matter content.

Although individual differences were in some cases fairly large, on an average the differences in yarn strength between the Delta and California cottons were too small to possess any great importance. The Arizona-New Mexico-Texas cottons produced yarns that were on an average about 5 percent weaker than yarns from the other two growths. This difference would probably be important in the selection of cotton for the manufacture of certain types of goods.

There was a close agreement between the results of skein and single strand yarn tests.

Tire cord made from the Delta cottons averaged 3.8 percent higher in strength than the California cord, and 8.0 percent higher than the Arizona-New Mexico-Texas cord. Cord elongation did not differ appreciably among growths.

In appearance of 22s yarn, the Delta cottons were on an average about two-thirds of a grade better than the California cottons, and

nearly one full grade better than the Arizona-New Mexico-Texas cotton. The relationships of the 60s yarn with respect to appearance were about the same as for 22s.

Fabric strengths were generally highest for the California cottons in the 1-1/16 and 1-1/8 inch lengths, but highest for the Delta cottons in the 1-3/32 inch length. The fabrics from both of these growths were higher in strength than the Arizona-New Mexico-Texas cottons of all three lengths.

In most cases the appearance of the unbleached, bleached, and dyed fabrics made from the Delta cottons was definitely better than that of the two irrigated growths. This was because of the greater freedom from neps, particles of foreign matter, and thick-and-thin places in the yarns of the Delta fabrics. Between the two irrigated growths there was no consistent difference in fabric appearance.

Color differences between unbleached samples of fabric were partially lost in the bleaching process and wholly masked when the samples were dyed. The Delta fabrics did not bleach quite so white as the irrigated fabrics, but appeared to absorb more dye in the dyeing process. The differences in color were large enough so that trouble would be caused in commercial manufacture if yarns spun from irrigated and rain-grown cotton were mixed indiscriminately in warp or filling.

Nep counts, which were made on one of the dyed sets of fabrics, gave averages of from 2.36 to 6.22 neps per square inch for the Delta fabrics; from 3.68 to 8.22 neps for the California fabrics; and from 4.72 to 10.92 neps per square inch for the Arizona-New Mexico-Texas fabrics. From 51 to 66 percent of the neps were lighter in color than the general color of the fabric.

No outstanding differences in manufacturing characteristics were noted for the three growths, and no difficulties were encountered during the spinning, twisting, warp preparation, or weaving of any of the cottons. Spinning end breakage was less for the California cottons than for the other two growths, except for the 1-1/8 inch cottons, in which the Delta cottons showed a slight advantage.

The findings of these tests, it is believed, provide a rather detailed and complete picture of the relative quality of the irrigated and rain-grown cottons included in this investigation. It should be remembered, however, that these results apply to cotton produced during only one season, namely, the crop of 1939. It will, of course, be necessary to obtain information of a similar type for other crop years before generalized conclusions can be drawn.

APPENDIX

Details of Test Procedure

At the spinning laboratory the individual bale sample tags were removed from the samples and the numbers were listed, to provide a means of identifying the individual bales if this appeared necessary later. Random samples were then drawn for each lot for color measurements, and small pinches or tufts of fibers were removed from each bale sample for fiber tests, and for Shirley analyzer tests. The remaining cotton for each area, set, grade and staple length was then subjected to the tests described below.

(a) Fiber tests. The pinches of fibers from the individual samples were combined for each lot, and the 81 fiber samples sent to the Service's fiber and spinning laboratories at College Station, Texas, for fiber tests. These included tests for length and length variability; fineness, in terms of average fiber weight per inch; immaturity, in terms of percentage of thin-walled fibers; and Chandler bundle strength. This work was carried out according to the regular procedure established by the Agricultural Marketing Service for these tests.

The fiber tests were made under controlled atmospheric conditions of 65% R. H. and 70°F.

For the samples of set No. 1, 3 length arrays and 10 Chandler bundles were tested per lot, whereas for sets Nos. 2 and 3, 2 length arrays were made and 5 Chandler bundles were tested for each.

(b) Spinning tests. Waste measurements were made in the usual manner, by weighing the cotton of each lot fed to and delivered by each cleaning machine, and by collecting and weighing each type of waste removed. Shirley analyzer tests were accomplished, under controlled humidity conditions, by passing a representative 100-gram sample of cotton through the analyzer twice, and weighing the cleaned cotton and the foreign matter removed.

The yarn manufacturing organization used for these tests is shown in figure 1. At some points the weight of stock differs somewhat from the usual mill organization for those particular yarn counts, but tests made in the Service's laboratories have shown that the differences in yarn quality resulting from them are negligible. The organization used was selected in the interests of efficiency and economy of effort, within limits that would not affect the test results.

Each lot of cotton was spun into 22s, 44s, and 60s warp yarn, with twist multipliers determined by preliminary tests to produce the highest skein strength for each growth and each staple length. These

twist multipliers were found to be 4.0 for the 1-1/16 inch and 1-3/32 inch samples, and 3.9 for the 1-1/8 inch samples. The cottons for the three different growths reacted in practically the same way to variations in twist, so that the same multiplier was used for all growths. Likewise, the same multiplier was used for all yarn counts, since tests made by the Service have shown this to be a constant factor for a particular cotton if highest yarn strengths are desired.

Tire cord designated as 23/5/3 was made from each lot of cotton, with a multiplier of 4.00, Z twist, in the single 23s, 18.0 turns per inch, Z twist, in the ply, and 8.0 turns per inch, S Twist, in the cable.

A quantity of 21s warp and 23.6s filling, with twist multipliers as indicated above, was made for the weaving of fabric samples from each of the 35 lots comprising set No. 1.

The following are some of the more important features of the spinning equipment used: Opening equipment consisted of a feeder and vertical opener, feeding the stock to a breaker picker with 2-blade beater revolving at 1060 R.P.M. The finisher picker was equipped with a Kirschner beater with a speed of 1000 R.P.M. Card speeds were: cylinder, 172 R.P.M.; lickerin, 430 R.P.M.; doffer, 10 R.P.M.; flats, 3¼ inches per minute. The average front roll speed of the drawing frame was 372 R.P.M. for both processes. Approximate roving twist multipliers were from 0.73 to 0.80 for slubber, from 0.82 to 0.88 for intermediate, and from 0.98 to 1.10 for fine frame roving. Spinning spindles revolved at 9500 R.P.M. for all counts up to and including 23.6s, 8750 R.P.M. for 44s, and 8500 R.P.M. for 60s. Leather-covered top rolls were used on all three lines of spinning rolls. Spinning rings were 1-1/2 inches in diameter.

In making the tire cord, 5 ends of 23s were wound parallel on a tube, with the use of a winder operating at 245 feet per minute. Twisting was accomplished on a ring twister, with spindle speed of 2620 R.P.M. and rings 4 inches in diameter.

During manufacturing, the relative humidity was maintained by manual control in the picker room to approximately 50 percent R.H., and by automatic control in the card and spinning rooms to 60 and 70 percent R.H., respectively. Atmospheric conditions in the testing laboratory were regulated automatically to 65 percent R.H. at 70°F.

As the various lots of cotton passed through the different machines, the behavior of each cotton was carefully observed, in an

effort to detect any important differences in manufacturing behavior. During the spinning of the 22s, 44s, and 60s yarns, records were made of the broken ends occurring. This information, together with the number of spindles used and the operating time per doff, formed a basis for calculating the rate of spinning end breakage per 100 spindles per hour. It is recognized, of course, that on so few spindles operated for so short a period, this index necessarily is limited in accuracy.

Physical tests of the yarns and cords were made in the laboratory as follows:

Test	Number of observations per lot
Skein strength and size	
22s	23 to 25
44s	35
60s	50
Single strand strength and size	
22s	470-480
44s	470-480
60s	470-480
Tire cord strength, size, elongation, and gage	25
Yarn appearance	2 (22s and 60s)

The skeins of yarn were tested for strength on a pendulum-type tester with lower spool descending at a rate of 1 foot per minute. They were tested for size on a magnetically damped quadrant balance. Sincle strand tests were made on a Moscrop automatic tester with loading speed adjusted to 1 foot per minute. Tire cord specimens were tested for strength and elongation on a pendulum-type tester fitted with standard tire cord jaws. An autographic recording device produced a stress-strain curve for each specimen, from which the elongation at a load of 10 pounds was determined graphically. Yarn appearance was measured by winding a specimen of yarn on a black board and comparing it with photographic grade standards. 4/

As far as possible, all tests were conducted according to standard methods recommended by the American Society for Testing Materials. 5/

4/ Campbell, Malcolm E. "Standards for appearance of cotton yarn." U. S. Dept., of Agriculture processed report. 8pp. April 1940.

5/ See the handbook, "A.S.T.M. Standards on Textile Materials", published in 1940 by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

(c) Weaving and testing of fabric. From each of the 35 lots of cotton comprising set No. 1 of the study, a small quantity (12 to 15 yards) of heavy cotton sheeting was made. The sheeting was approximately 11-3/4 inches wide, with a nominal construction of 68 X 72, and a nominal weight of 4.90 ounces per square yard. The warp yarn was 21s, and the filling, 23.6s.

Each warp was prepared on a special machine developed in the laboratory of the Agricultural Marketing Service. This machine permits a small warp to be sized and dried, and wound on a loom beam, directly from a group of spinning bobbins in the creel. Eight hundred and twenty-six ends were obtained in 14 sections from 59 bobbins. Approximately 7 percent size was applied to the warps.

The fabric was woven on a special narrow loom, operating at a speed of 134 picks per minute. A relative humidity of 70 percent was maintained during weaving.

The grey cloth from each lot was tested for the following properties, in addition to weight per square yard, and construction:

Test	Number of observations per lot
Resistance to tear (tongue method)	
warpwise	10
fillingwise	10
Tensile strength (grab method)	
warpwise	25
fillingwise	25
Bursting strength (diaphragm method)	25
Surface foreign matter particles per square inch	90

In addition to the above tests, the grey samples of sheeting were carefully compared for appearance. Also, photographs in natural size and by the use of transmitted light were obtained for each sample, in order to bring out the imperfections. These photographs were of considerable help in the comparisons of the fabrics with respect to appearance.

(d) Bleaching and dyeing of fabric. The bleaching and dyeing of the fabric samples were carried out in the textile dyeing laboratories of the Clemson Agricultural College. 6/ Several yards of fabric

6/ See footnote 2.

woven from each of the 35 lots of set No. 1 were sewed together to form a continuous length. This material was then desized by soaking it overnight in a 200-gallon solution containing 4 pounds of a desizing compound. Following this treatment the material was rinsed in warm water and boiled for about 6 hours in a mixture of 4 pounds of soda ash and 3 pounds of keir boiling oil in 200 gallons of water. A hot rinse and a second boiling, this time for 4 hours, were then given the fabric, followed by a rinse with boiling water.

The fabric was then bleached in a bleaching powder solution of normal strength, rinsed in cold water and soured in a 1 percent solution of hydrochloric acid. A cold rinse and an antichlor treatment in a solution of 5 pounds of sodium bisulphite to 200 gallons of water then followed. It was again rinsed in cold water and soaped in approximately 3 pounds of soap to 200 gallons of water at 140°F. It was then blued in the same bath with Lizarine Blue-SAP, drained, and dried. That part of each sample that was not to be dyed was ironed by hand, and reserved for inspection and color measurements.

All fabric samples to be treated with a particular dye bath were dyed in one bath at the same time. After they had been placed in the dye bath, the samples were stirred continually with a rod, and at the conclusion of the treatment they were removed and hung horizontally in a heated drying room until they were dry. They were then placed under a damp cloth and ironed by hand until they were smooth and free from wrinkles.

Six dyeing treatments were used, with a different batch of bleached samples in each case. These treatments included the use of a normal as well as a dilute solution of each of the following dyes: Solantine Blue 4 GL (2% and 1/2%); Solantine Black L (1% and 1/2%); and Ponsol Direct Black 3 G (20% and 3%).

The solantine dyes are commonly used direct dyes that are fast to light but not to washing and bleaching. The samples were dyed for about 2 hours at a boiling temperature, in baths made up of water, dye, soap, sodium phosphate, and salt.

Ponsol Black is a vat dye possessing maximum fastness to all tests. The samples in this study were dyed for about 1 hour at a temperature ranging between 140°F and 160°F in a bath containing the dye and caustic soda and sodium hydrosulphite as reducing agents. Following the dyeing process the samples were oxidized with sulphuric acid and sodium nitrite, and then boiled for a short time in a bath containing soap.

Because of streaks in the color of the fabrics after the first dyeing process, it was necessary to dye the dark shades of Ponsol Black and Solantine Black twice, and the dark shade of Solantine Blue three times.

(e) Color tests of fabric. Specimens of fabric averaging about one-half yard each in length were subjected to color measurements. 7/ Included in these tests were the unbleached and bleached samples, and those that had been dyed with the normal concentrations of Solantine Blue 4 GL and Ponsol Direct Black 3G. Spectrophotometric curves were made for samples approximating the extreme colors for each of these series. Brightness measurements of all samples in each series were made at a single wave length. Since the spectrophotometric curves were of the same general shape, these figures for brightness of a single wave length gave a picture of the relative color differences represented in each set of conditions.

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7/ See footnote 2.